IESALC | ILLUMINATING ENGINEERING SOCIETY of NORTH AMERICA
AVIATION LIGHTING COMMITTEE

Green Airport

GO FOR GREEN AIRFIELD

Trends and solutions (v.5)

Gil DAVER & Bernard BAEYENS
Abroad Business Consultants ltd

GREEN AIRFIELD SUMMARY

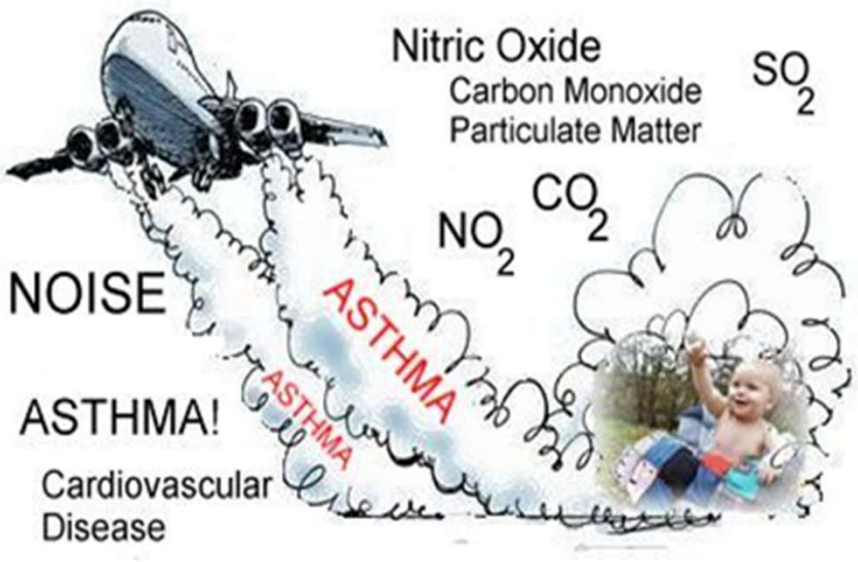
Green Airport

- Airfield Pollutions
- Airfield, Full of Solar Energy
  - PV & CSP Solution
  - Solar at Airfields
- Solar Solution **HELIO STRIP**
  - Frangible PV on airport strip
  - Example, Standards, Solutions
- Solar Solution **HELIO APRON**
  - PV and CSP over aircraft on apron
  - Power & Aircon solutions
- CONCLUSIONS

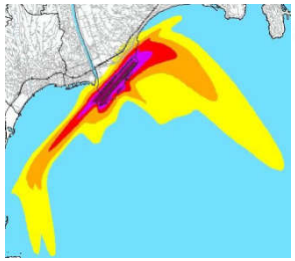
AIRFIELD POLLUTIONS

Green Airport

Green Airport



1. Noise



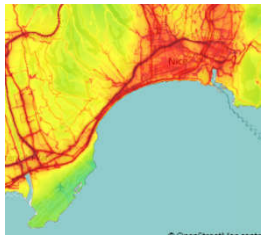
2. CO2

Empowering airports to address their carbon emissions

airport carbon accreditation

MAPPING | REDUCTION | OPTIMISATION | NEUTRALITY

3. NO2, SO2, Others …



GO-GREEN

AIRFIELD POLLUTIONS

Green Airport

airport carbon accreditation
MAPPING | REDUCTION | OPTIMISATION | NEUTRALITY

What could be done in airports?

- Carbon footprint to be reduced
- Compensate carbon production = Zero Carbon objective
- Overcompensate carbon production = Carbon + objective

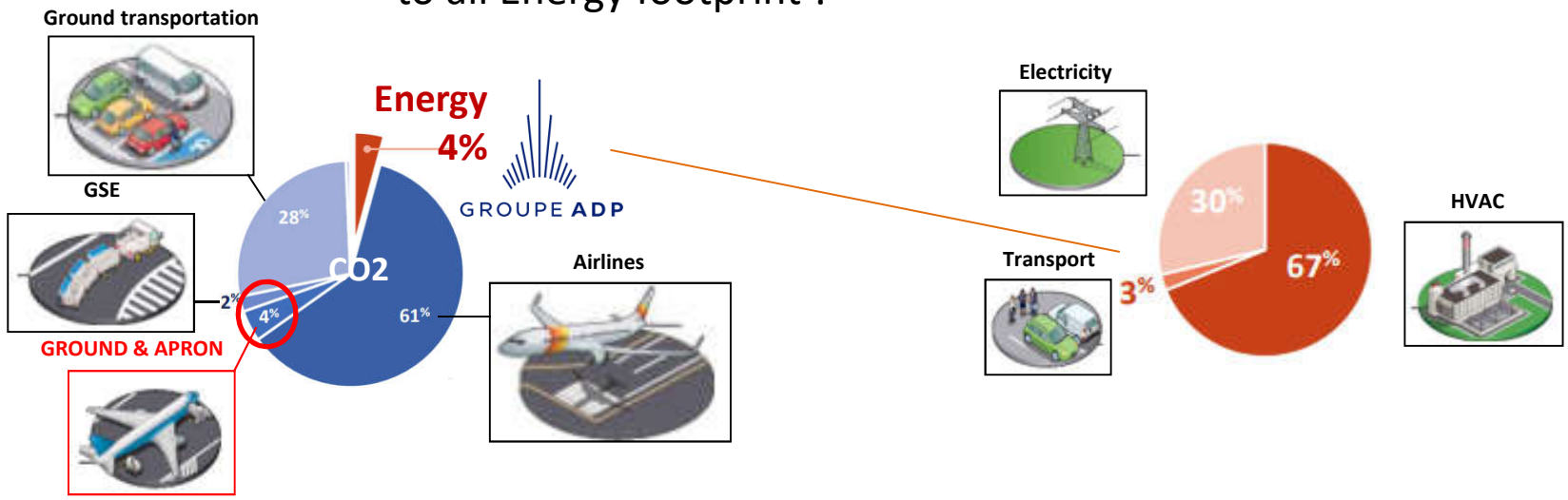
Infos from Green Airport day on November 23rd, 2017

Paris Aeroports (ADP) example > Carbon Accredited Level 3

Energy = 4% of ADP Group CO2 footprint

- 67% from Heating Ventilation and Air Conditioning
- 30% for all electrical power needs

GROUND & APRON APUs carbon pollution at 4% is equivalent to all Energy footprint !



GO-GREEN

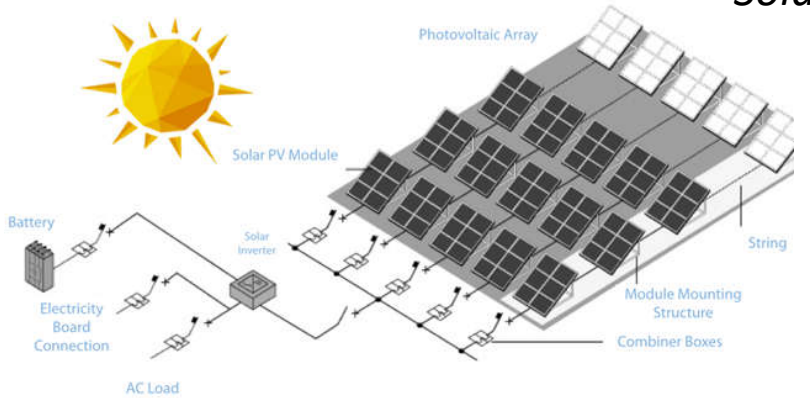
Airfield, Full of Solar Energy

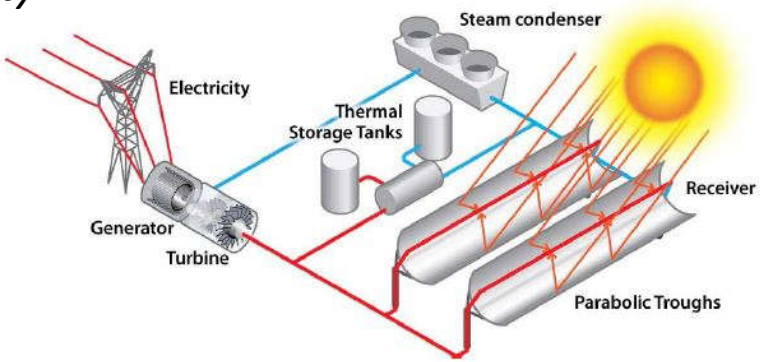
Green Airport

PV Solution

CSP Solution

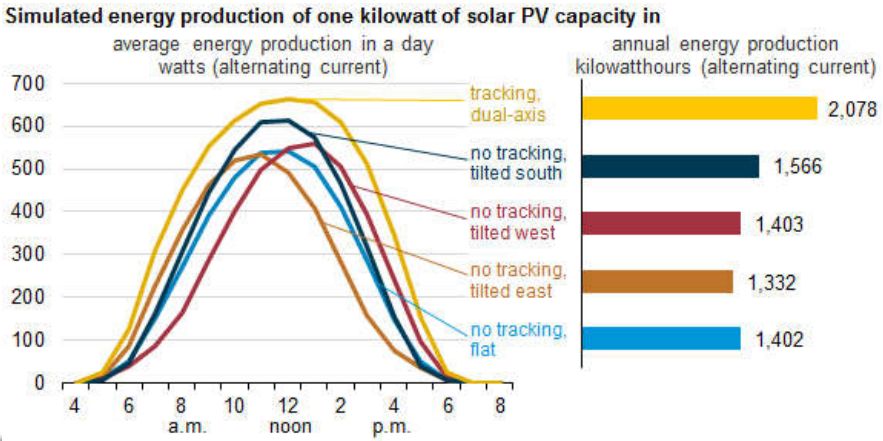
Solar to Electricity

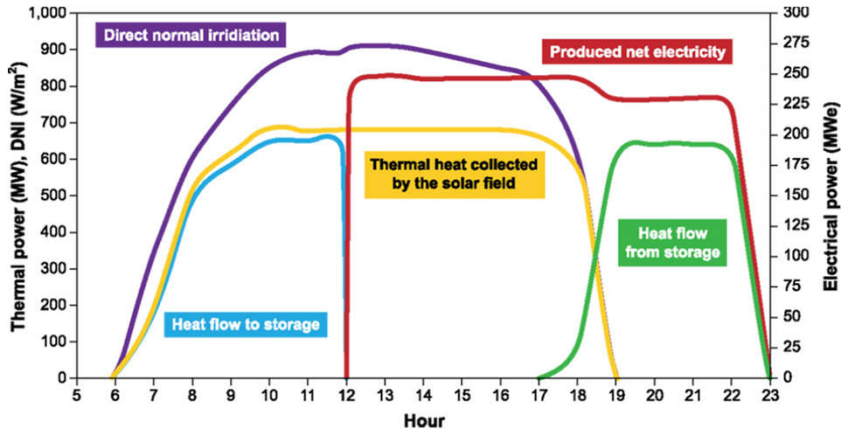




Efficiency: 1,000W/m² → 150+ Wpeak output

Efficiency: 1,000W/m² → 250 Wpeak output





Low cost but no storage

High cost but storage

GO-GREEN

Airfield, Full of Solar Energy

Green Airport

Antigua Airport, Carribean

San José Airport, USA

Cochin Airport, India

Neuhardenberg Airport , Germany

Setouchi Kirei Airport, Japan

Nice Airport, France

Kimberley Airport, South Africa

GO-GREEN

HELIO STRIP

Green Airport

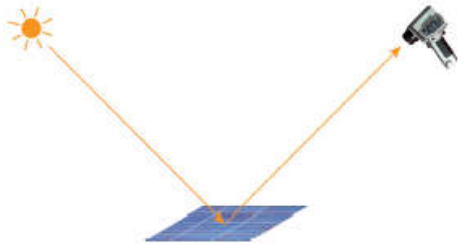
VISUAL RISK
Differentiation & Colour
Glaring

DGAC Partnership

(DGAC = the French Civil Aviation Department)

SOLERO

Experiment on
the visual discomfort
related to the installation of solar panels



Measurement of luminance (cd/m2) from solar panels on the ground

Tests report

Version :	**V2 du 16/09/2010**
Rédacteur :	**Pierre THERY**
Référence :	**RAP/STAC/ACE/VOLTA/10-431**

Dr Bronislaw KAPITANIAK

Ergonomist

Risk assessment methodology

RISK ASSESSMENT MATRIX

Likelihood	Severity: Negligible	Marginal	Critical	Catastrophic
Frequent				
Probable				High
Occasional			Serious	
Remote		Medium		
Improbable	Low			

FEDERAL AVIATION ADMINISTRATION — APPROVED — EASA European Aviation Safety Agency

Luminance < 20,000 cd/m² *(white wall glare …)*

GO-GREEN

HELIO STRIP

Typical

Green Airport

ELECTRICAL RISK
Electromagnetic Compatibility EMC
Open-circuit

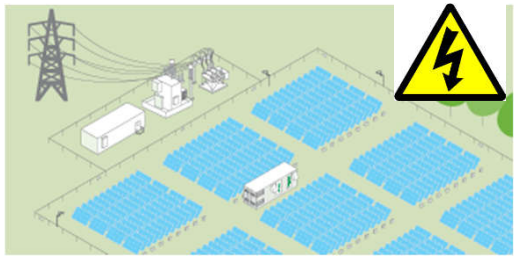
A **PV module** is a **current generator** working *like airfield lighting systems with* ***constant current generators***

Model	SPR-P17-330-COM
Nominal Power (Pnom)	330 W
Power Tolerance	+5/–0%
Efficiency	16,0%
Rated Voltage (Vmpp)	41.9 V
Rated Current (Impp)	7.88 A
Open-Circuit Voltage (Voc)	50.9 V
Short-Circuit Current (Isc)	8.47 A

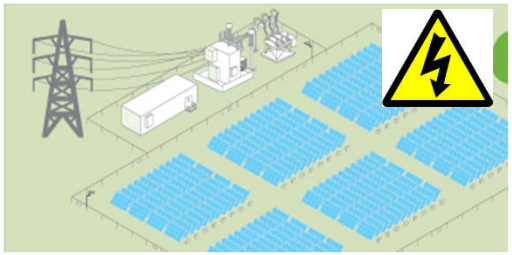
- A single module in short-circuit has about 8,5 A current
- A single module in open circuit is close to 50 VDC
- **20 serial modules** will operate with **1,000 VDC in open-circuit** under the sun
- 20 modules will all work in serie with the current level of the *weaker* module (as batteries)

⇒ **High electrical risks in the event of accident or fire !!**

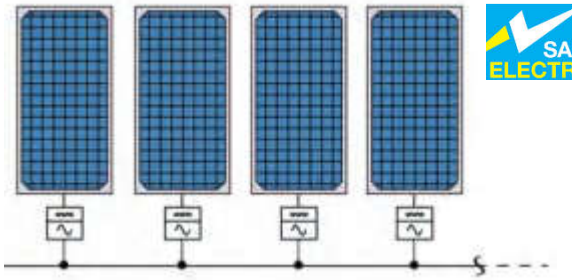
⇒ **No way to stop power generation when sun shines**



Centralised PV
With big string
DC/AC inverters
Typical 1 MW shelter



De-centralised PV
With small string
DC/AC inverters
Typical 10 kVA

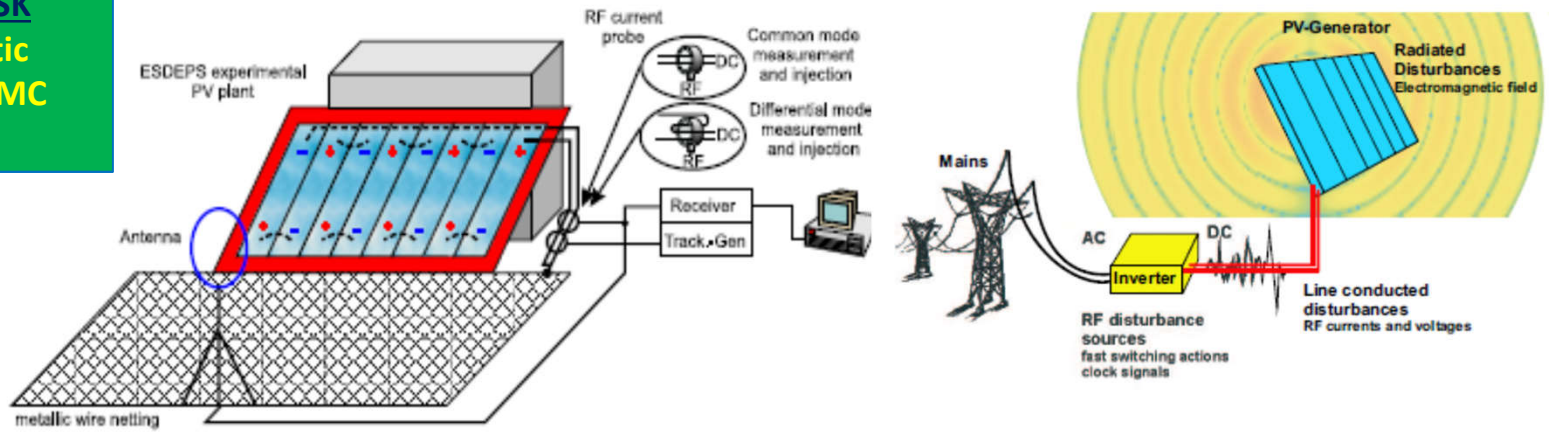


Fully de-centralised PV
With DC/AC **micro-inverters**
On each module

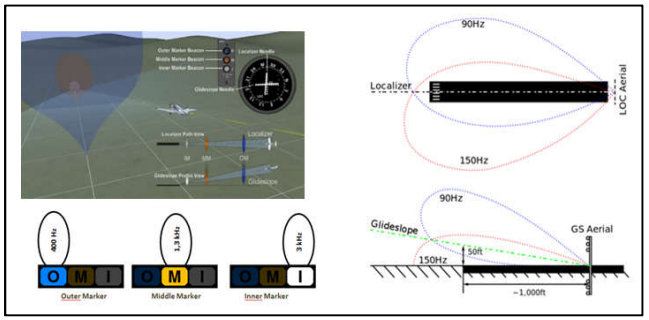
GO-GREEN

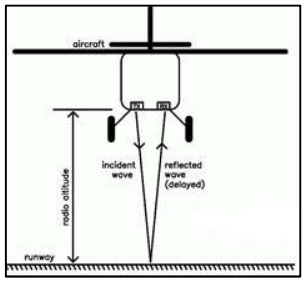
HELIO STRIP

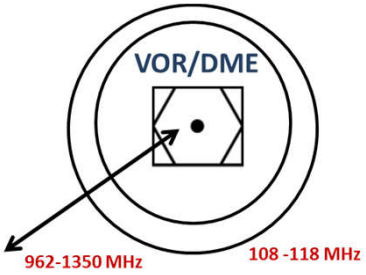
ELECTRICAL RISK
Electromagnetic Compatibility EMC
Open-circuit



Photovoltaic test setup for antenna and field strength measurement





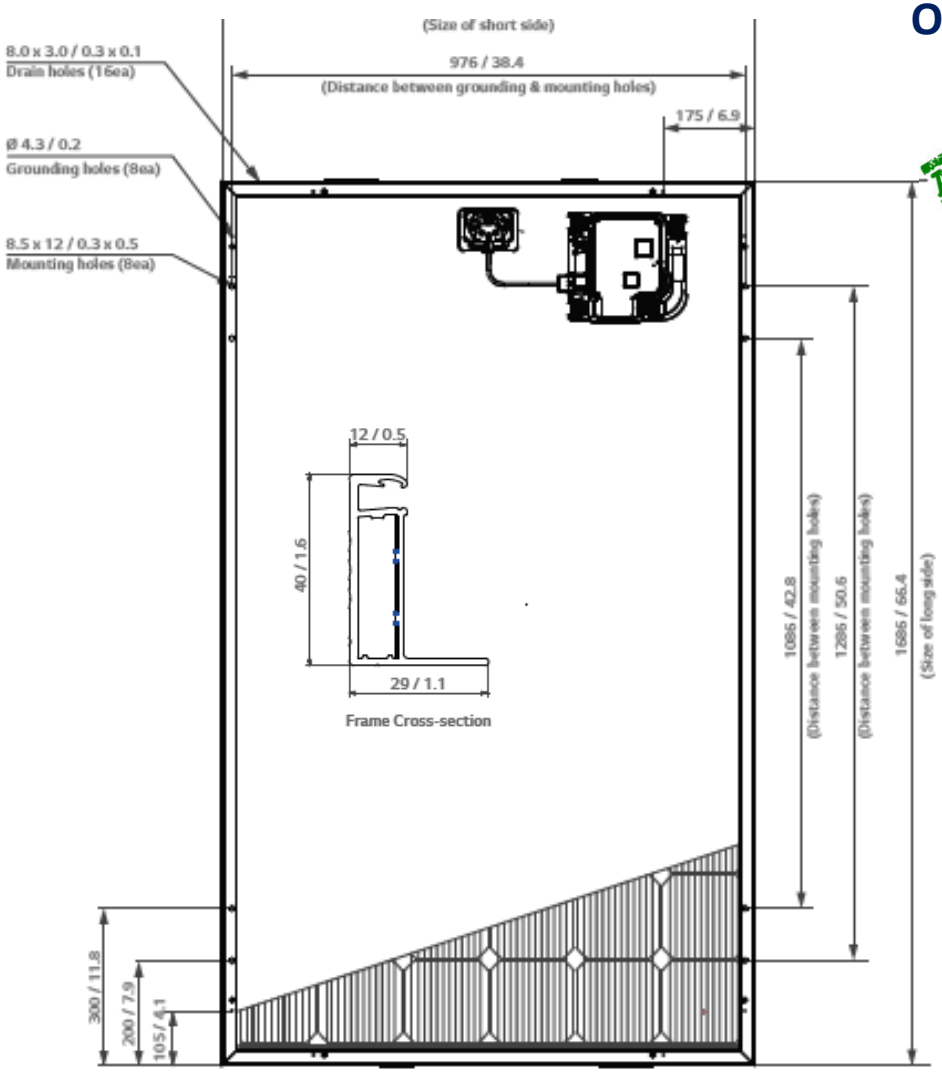


CE

LG NeON® 2 ACe

LG330E1C-A5

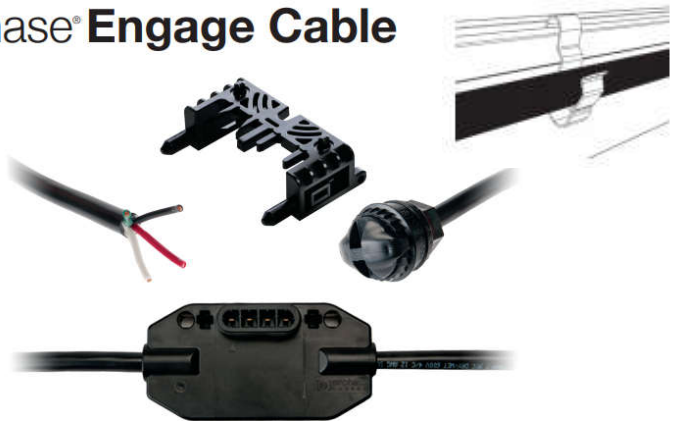
Dimensions (mm/in)



EMC
Open circuit

APPROVED

Enphase® Engage Cable



Enphase IQ Envoy

CAPACITY	
Number of microinverters polled	Up to 600

DC Electrical Properties (STC*)

Module	330 W

AC Electrical Properties

Peak Ou tput Power (VA)	290
Max. Continuous Output Power (VA)	280
Nominal Voltage / Range (V)	240 / 211 – 264
Nominal Output Current (A)	1.17
Nominal Frequency / Range (Hz)	60.0 / 59.3 – 60.5
Power Factor / Adjustable	1/0.7 leading...0.7 lagging
CEC Weighted Efficiency (%)	97.0
Max. Branch Circuit Over Current Protection	20
Number of Max. AC Modules (EA)	13

Enphase based in CALIFORNIA, USA

GO-GREEN

HELIO STRIP

Green Airport

MECHANICAL RISK
Attachment
Frangibility

Aircraft running out runway

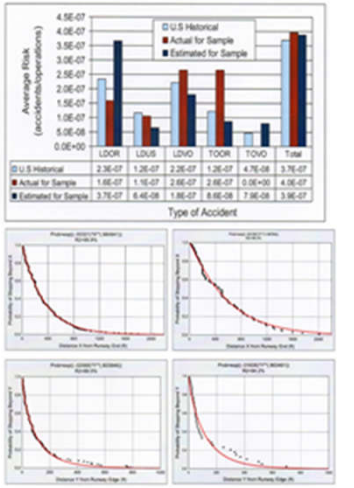
**** Ratio of this type of accident***
- On 2010: 21% of accidents

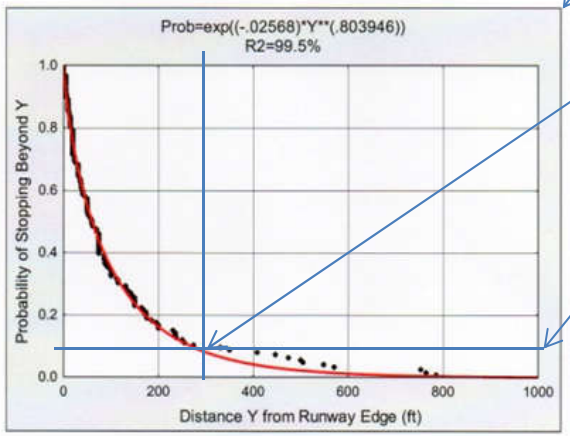
**** Low probability***
- 0.4 case / million of operations

**** Run out in the axis***
- Landing & takeoff

**** Lateral Run out***
- Mainly during landing
- Low traveled distance

80% lower than 80m from runway





At 105 meters from the runway axis
If Runway Edge = 30 meters => **75m or 246 ft**

10% x 0.4 case / million
= 40 cases / billion of operations

<u>Example:</u> Airport with 150,000 operations/year
⇒ 1 risk every 167 years
⇒ But can statistically happen the first year !

GO-GREEN

CHAPTER 3. PHYSICAL CHARACTERISTICS

3.4 Runway strips

Width of runway strips

3.4.3 A strip including a precision approach runway shall, wherever practicable, extend laterally to a distance of at least:

— 150 m where the code number is 3 or 4; and

— 75 m where the code number is 1 or 2;

on each side of the centre line of the runway and its extended centre line throughout the length of the strip.

3.4.7 No fixed object, other than visual aids required for air navigation purposes and satisfying the relevant frangibility requirement in Chapter 5, shall be permitted on a runway strip:

a) within 77.5 m of the runway centre line of a precision approach runway category I, II or III where the code number is 4 and the code letter is F; or

b) within 60 m of the runway centre line of a precision approach runway category I, II or III where the code number is 3 or 4; or

c) within 45 m of the runway centre line of a precision approach runway category I where the code number is 1 or 2.

No mobile object shall be permitted on this part of the runway strip during the use of the runway for landing or take-off.

ATTACHMENT A. GUIDANCE MATERIAL SUPPLEMENTARY TO ANNEX 14, VOLUME I

8.3 Grading of a strip for precision approach runways

Chapter 3, 3.4.8, recommends that the portion of a strip of an instrument runway within at least 75 m from the centre line should be graded where the code number is 3 or 4. For a precision approach runway, it may be desirable to adopt a greater width where the code number is 3 or 4. Figure A-4 shows the shape and dimensions of a wider strip that may be considered for such a runway. This strip has been designed using information on aircraft running off runways. The portion to be graded extends to a distance of 105 m from the centre line, except that the distance is gradually reduced to 75 m from the centre line at both ends of the strip, for a length of 150 m from the runway end.

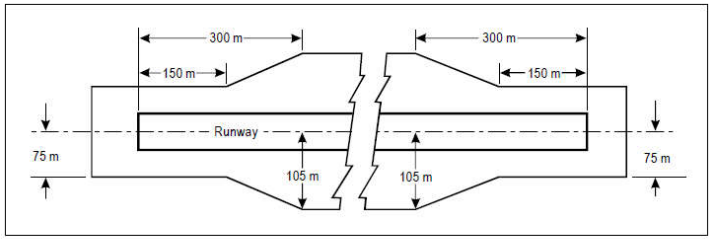
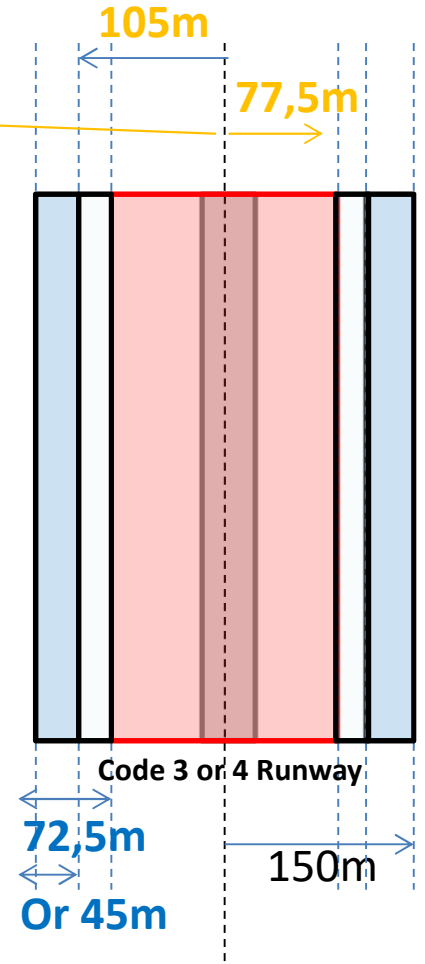


Figure A-4. Graded portion of a strip including a precision approach runway where the code number is 3 or 4

Green Airport

Annex 14
to the Convention on International Civil Aviation



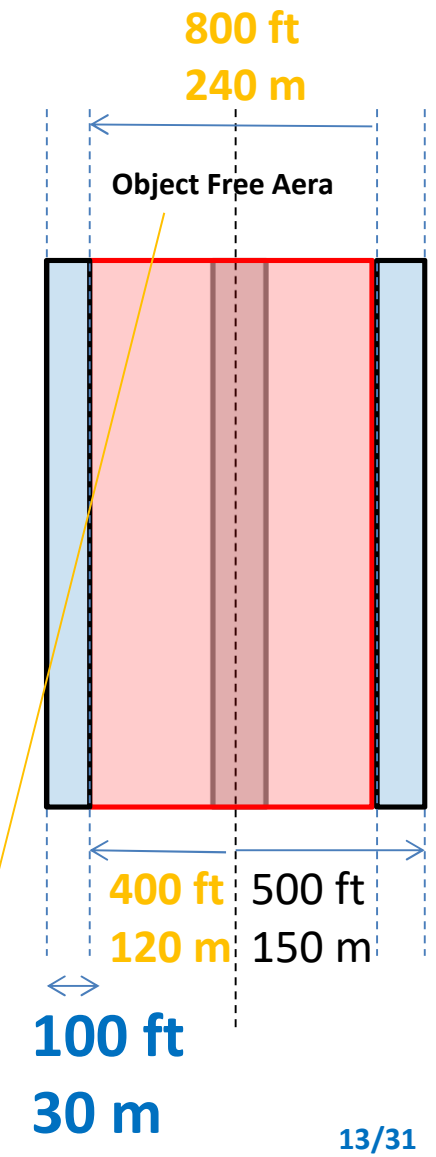
HELIO STRIP

United States Department of Transportation

FAA requirement fro the Object Free Aera (O.F.A)

307. OBJECT FREE AREA. The runway object free area (OFA) is centered on the runway centerline. The runway OFA clearing standard requires clearing the OFA of above ground objects protruding above the runway safety area edge elevation. Except where precluded by other clearing standards, it is acceptable to place objects that need to be located in the OFA for air navigation or aircraft ground maneuvering purposes and to taxi and hold aircraft in the OFA. Objects non-essential for air navigation or aircraft ground maneuvering purposes are not to be placed in the OFA. This includes parked airplanes and agricultural operations. Tables 3-1, 3-2, and 3-3 specify the standard dimensions of the runway OFA. Extension of the OFA beyond the standard length to the maximum extent feasible is encouraged. See figure 2-3.

ITEM	DIM 1/	AIRPLANE DESIGN GROUP					
		I	II	III	IV	V	VI
Runway Length	A	- Refer to paragraph 301 -					
Runway Width	B	100 ft	100 ft	100 ft 2/	150 ft	150 ft	200 ft
Runway Object Free Area Width	Q	800 ft	800 ft	800 ft	800 ft	800 ft	800 ft
		240 m	240 m	240 m	240 m	240 m	240 m

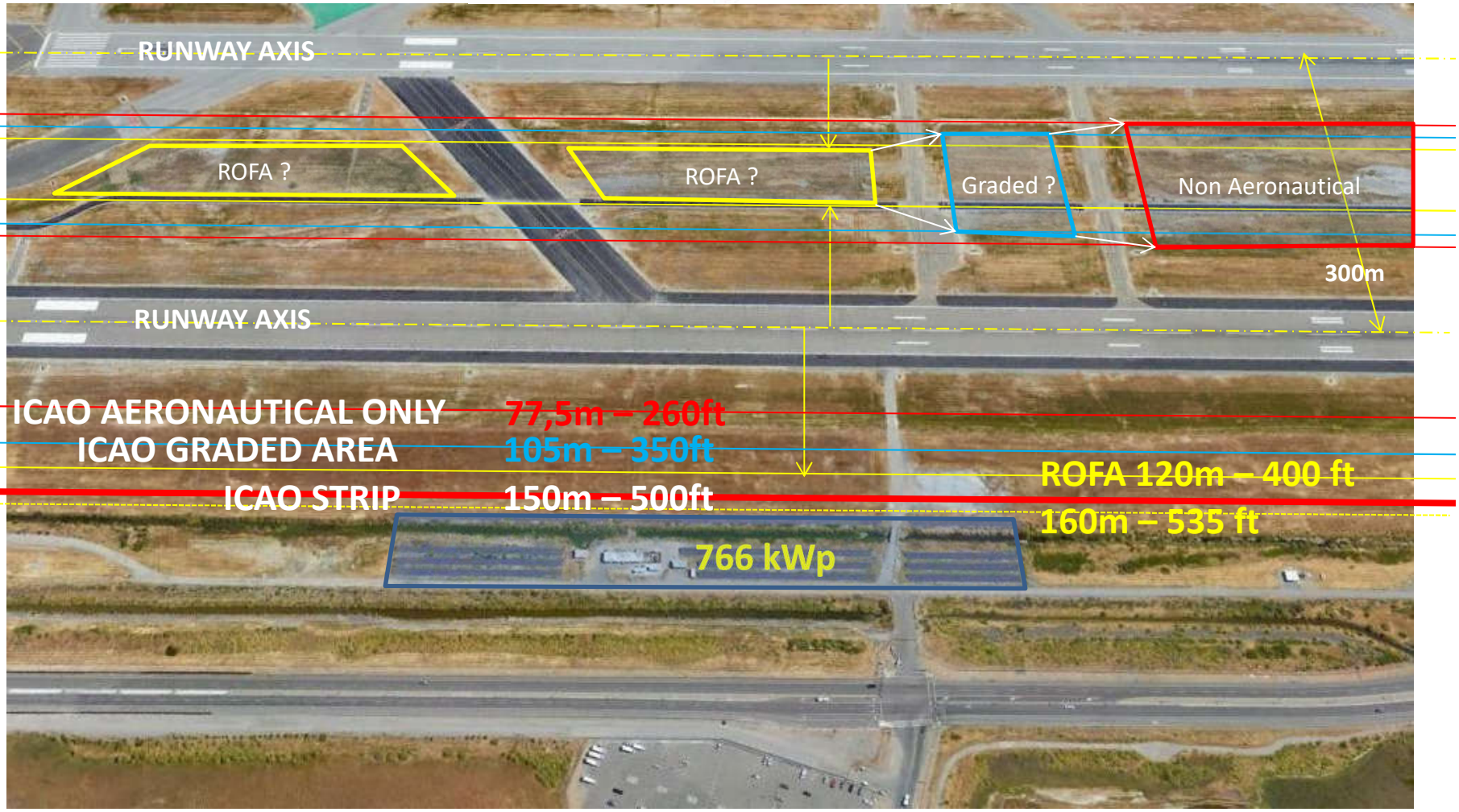


HELIO STRIP

Voluntary Airport Low Emissions (VALE) Program

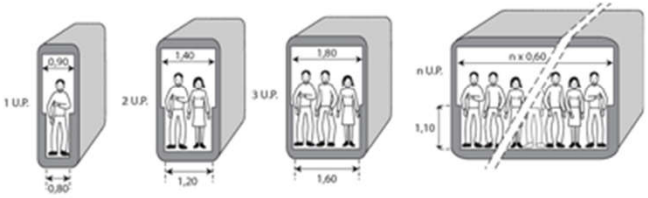
OAKLAND INTERNATIONAL AIRPORT I ✈ OAK

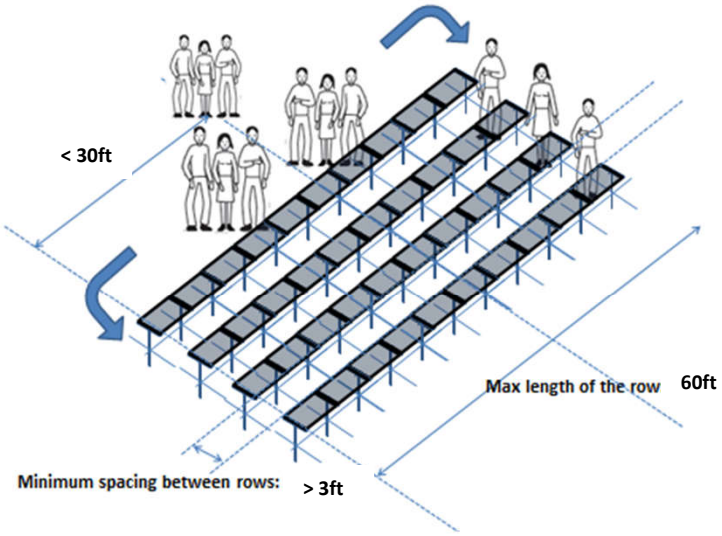
Green Airport

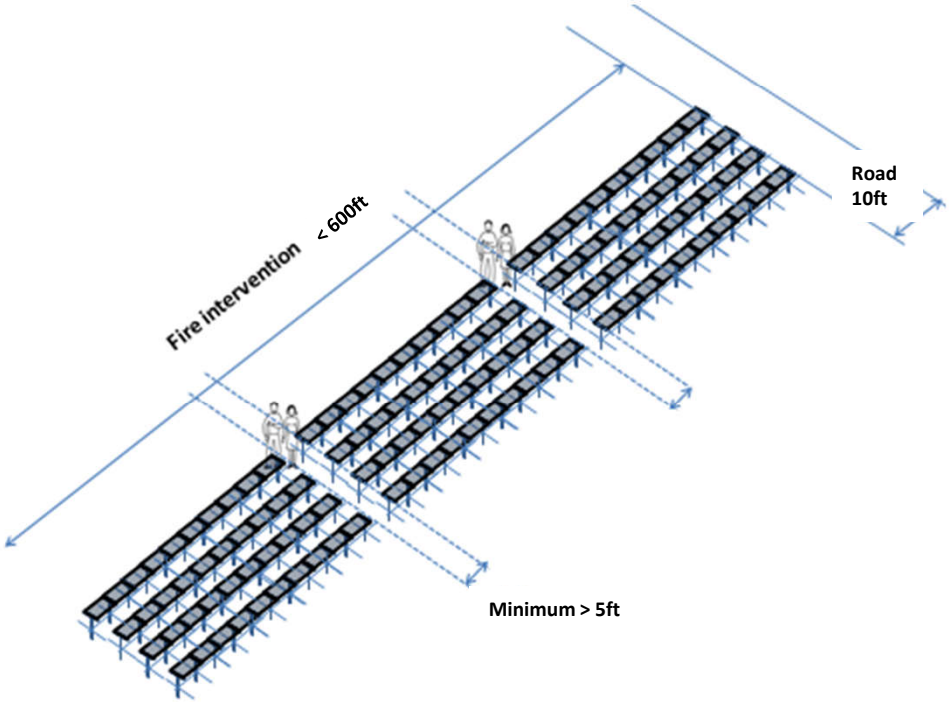


HELIO STRIP

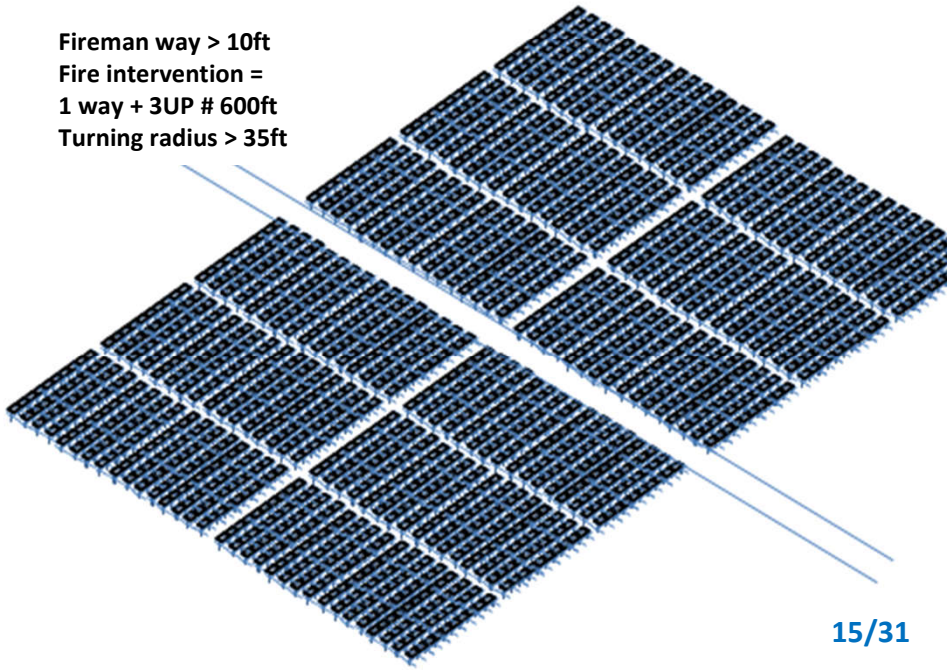
FIRE & RESCUE

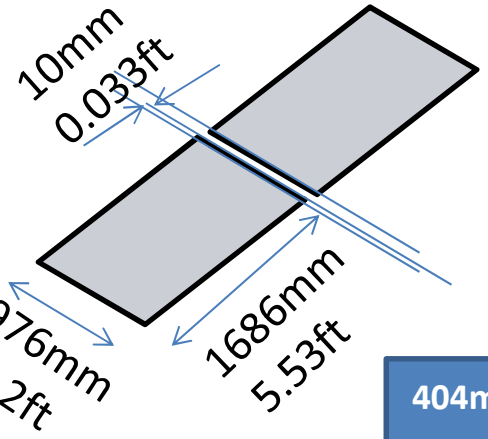






Fireman way > 10ft
Fire intervention =
1 way + 3UP # 600ft
Turning radius > 35ft





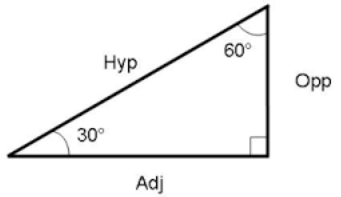
1 block = 132 PV panels
1 panel = 290 VA peak
→ Total: 38 kVA
S=404m² - 4,350 sqft
→ 94 VA/m² or
8.7 VA/sqft

404m²
4,350 sqft

SPACING !

11 raws -> 19,871m (65.2ft)

12 panels -> 20,342m (66.7ft)



Cos(angle) = Adj/Hyp
If Hyp = 1 => Cos(30°) = 0.866

If 15° → 0.95m (approx. 3ft)

cosinus

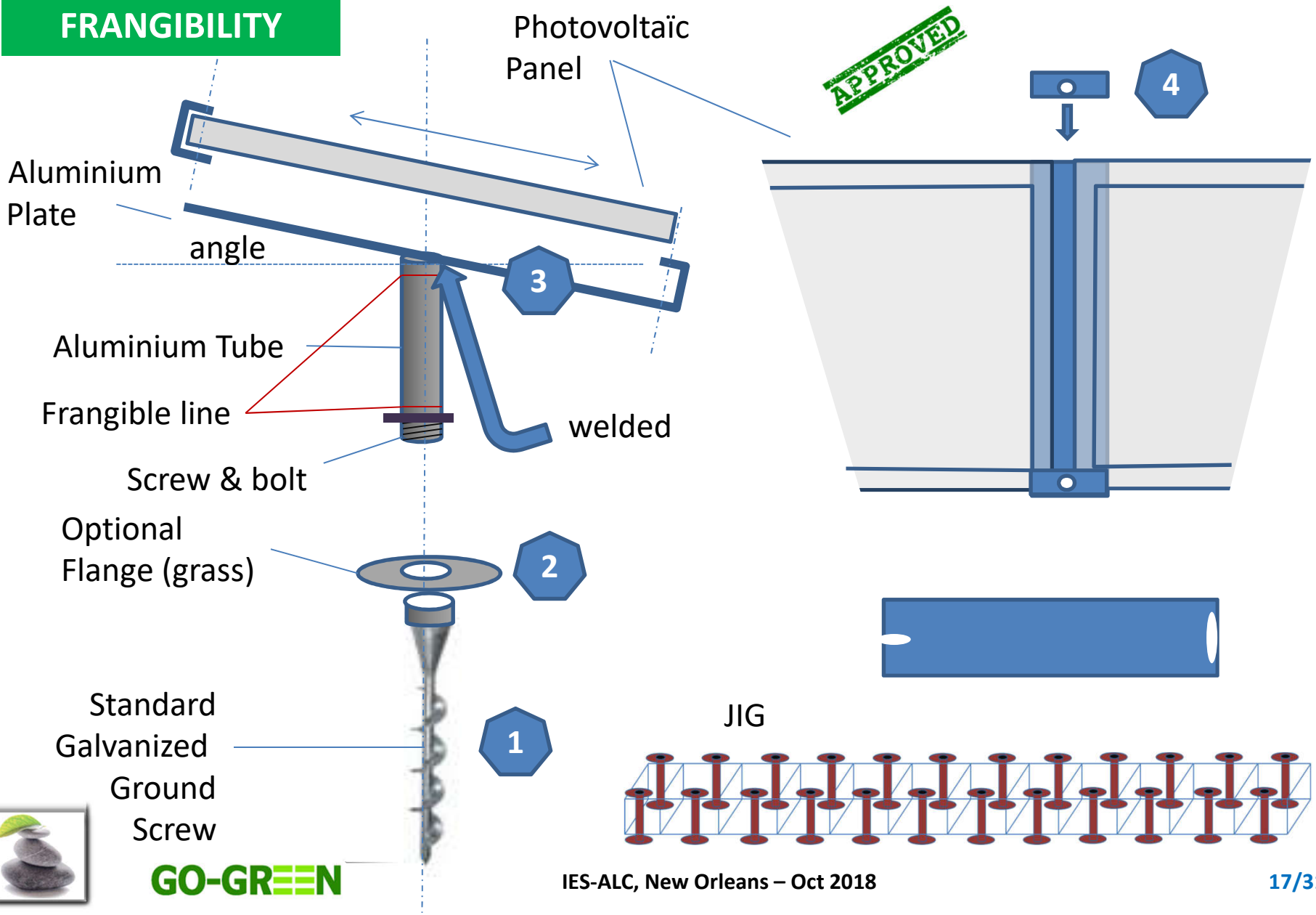
Exposure 10°	Exposure 15°	Exposure 20°	Exposure 25°	Exposure 30°
0.985	0.966	0.94	0.906	0.866

				Exposure 10°	Exposure 15°	Exposure 20°	Exposure 25°	Exposure 30°
LG solar panel	Length	1686	mm					
Ground plan	Width	976	mm	961	943	917	884	845
Panels number in the width		11						
Space between panels			m	0,9	0,95	1	1,1	1,15
Total (meters)				19.575	19.871	20.092	20.727	20.797

HELIO STRIP

Green Airport

FRANGIBILITY



GO-GREEN

HELIO STRIP

Green Airport

Machines, tools & lawn mower robot

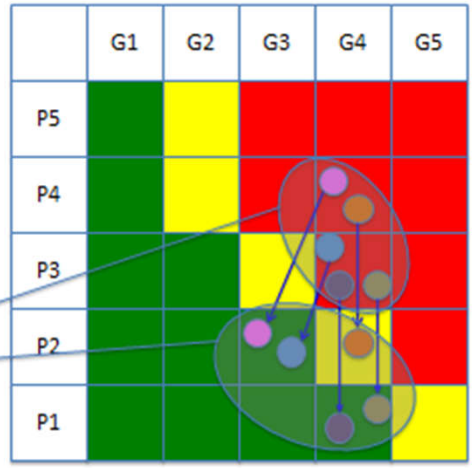
[See http://www.schraubfundamente.de/en/eindrehmaschinen/](http://www.schraubfundamente.de/en/eindrehmaschinen/)

HELIO STRIP RISKS ANALYSIS
with SOLERO solutions

- Foreign object on runway
- Network under voltage
- Pull out by the wind
- Aircraft fire
- Evacuation of passengers

Standard PV solar plant

SOLERO airport solar plant



3. SOLERO solutions

List of constraints (Regis HELLOT – SETEC consulting)

3.1. Glare management

3.1.1. 3D Simulator (SETEC or SOLAIS) + an US Software « **FORGESOLAR** »
→ from **Solar Glare Hazard Analysis Tool** (SGHAT)

3.1.2. Glass treatment, advantages, disadvantages, solar panel conformity with luminance levels (Bernard Baeyens - ABC)

3.2. Electrical safety (→ Solar micro-invertor Enphase)

3.2.1. Individual panel safety

3.2.2. Frangible connectors

3.2.3. Transport and energy conversion

3.3. Mechanical safety

3.3.1. 3D simulation for the PV panel support (Millard Tower)

3.3.2. SOLERO Solution for the complete plant (Bernard Baeyens – ABC)

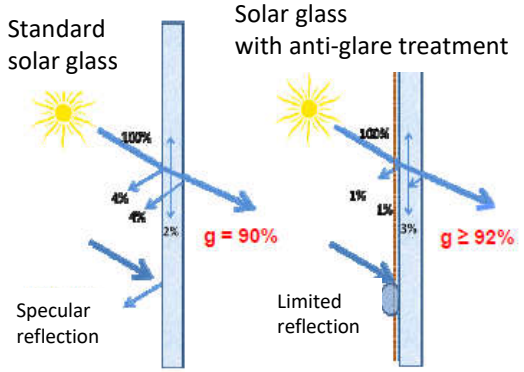
3.4. Others constraints

3.4.1. During the installation process (Bernard Baeyens – ABC)

3.4.2. For maintenance actions (Bernard Baeyens – ABC)

SOLERO

3.1. SOLERO solution (Glare)



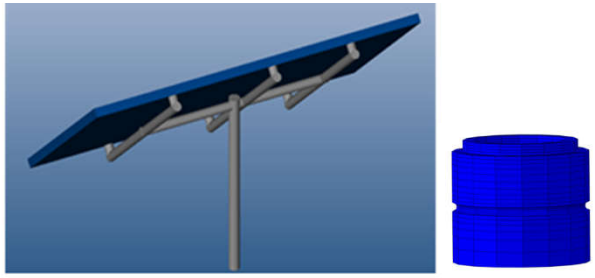
3.2. Enphase solution (DC/AC + EMC)

Micro-inverter +
frangible cabling

3.3. SOLERO Mechanical solution

3D Simulation for the mechanical frangibility (Millard Tower)

- Conception constraints:
  - **Operation**: wind (150 miles/h), Temperature (-15 to 120°F), Ice (0.5 inch thickness)
  - **Frangibility**: broken with anaircraft impact (3 tons, 30 miles/h)
  - **Cost**: looking after a easy solution



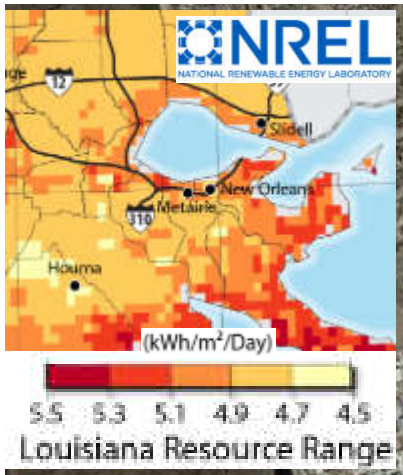
HELIO STRIP

Green Airport

Louis Armstrong New Orleans International Airport

84Ha runway strip land requiring frangibility -> 750.000 m² for use

Ratio 50% at 175Wp/m² => **66 MW peak PhotoVoltaic solar plant**



PV Frangible Structures
Inclination 20°

66 MWp at 1,515 kWh/kWp => 100 GWh electricity per year

100 million kWh « green » electricity produced per year

GO-GREEN

GREEN AIRFIELD SUMMARY

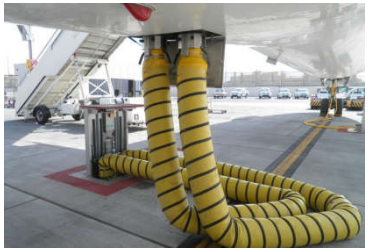
Green Airport

- ✓ Airfield Pollutions
- ✓ Airfield, Full of Solar Energy
  - PV & CSP Solution
  - Solar at Airfields
- ✓ Solar Solution **HELIO STRIP**
  - Frangible PV on airport strip
  - Example, Standards, Solutions
- Solar Solution **HELIO APRON**
  - PV and CSP over aircraft on apron
  - Power & Aircon solutions
- CONCLUSIONS

HELIO APRON

Green Airport

APU stop? → Existing Solutions for aircrafts

	Mobile With generator **diesel**	**Semi-mobile** Electrical power Under PBB	**Fixed** Electrical power On the floor	**Fixed** Electrical power or centralized
PCA Air Con →				
GPU 400Hz →				
NEW at 2017 InterAirport				

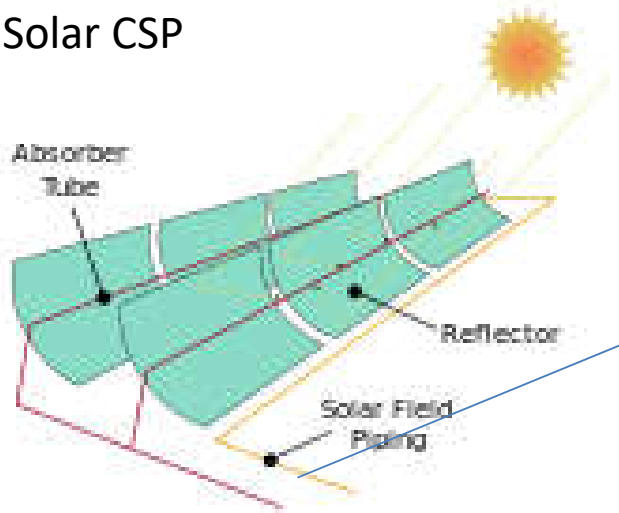
APU stop? → HELIO APRON
A Go Green airport solution

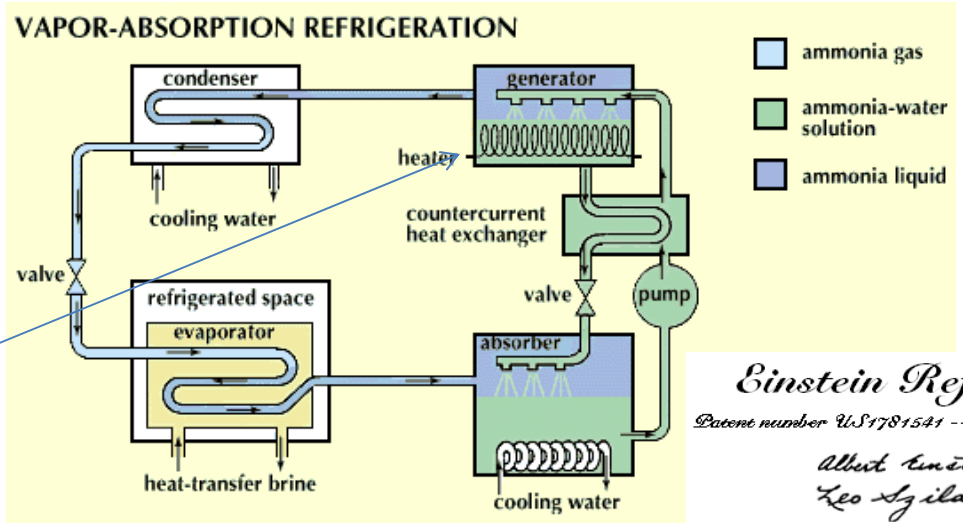
Air Conditioning Solution

Green Airport

Thermodynamic cycle

Solar CSP





Einstein Refrigerator
Patent number US1781541 -- November 11, 1930
Albert Einstein
Leo Szilard

or/and

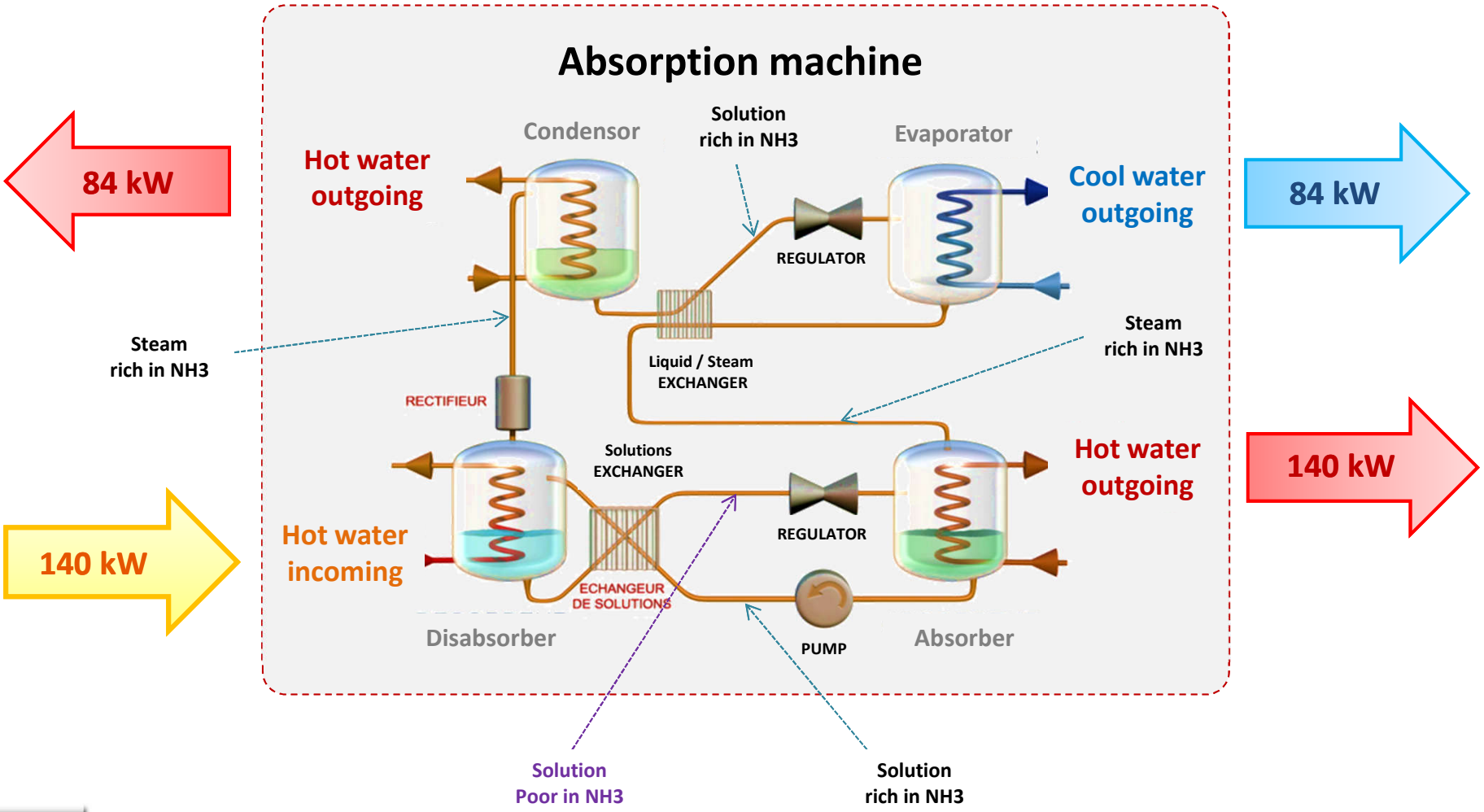
Biogas
Biomass

NOTE:
1 kg refrigerant gas
⇔ 12,000 tons of CO2

Air Conditioning Solution

Green Airport

EFFICIENCY

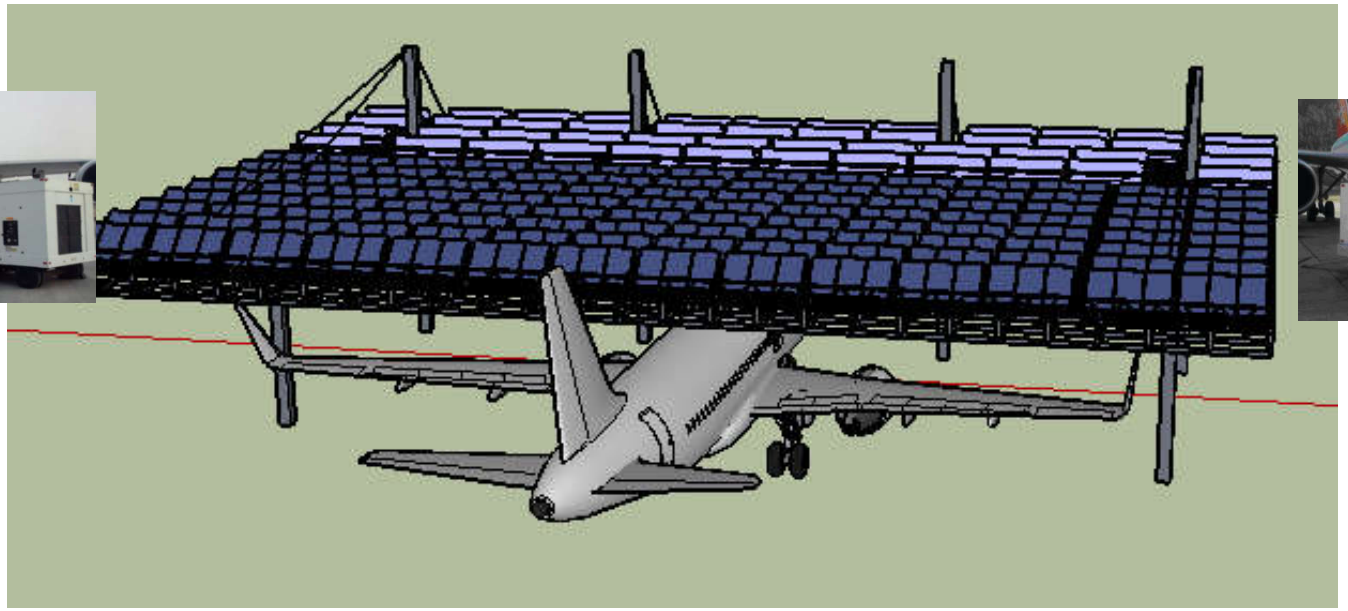


HELIO APRON

Green Airport

IDEAS

Aircraft Shading → Heat reduction



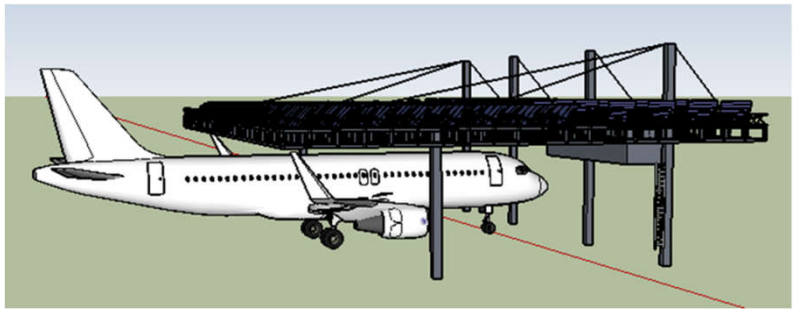
PCA

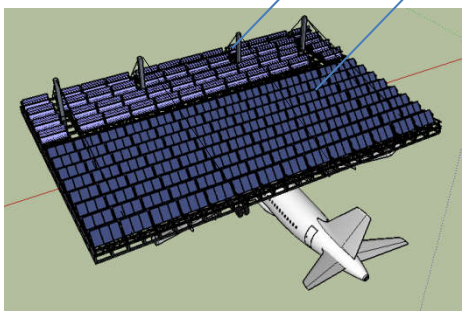
APU

400Hz

CSP

PV





AIR QUALITY ALERT

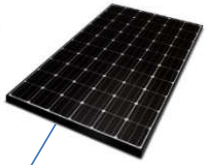
CO_2

HELIO APRON

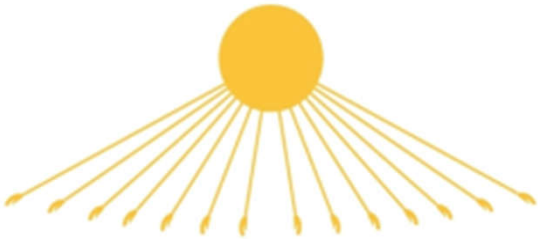
Green Airport

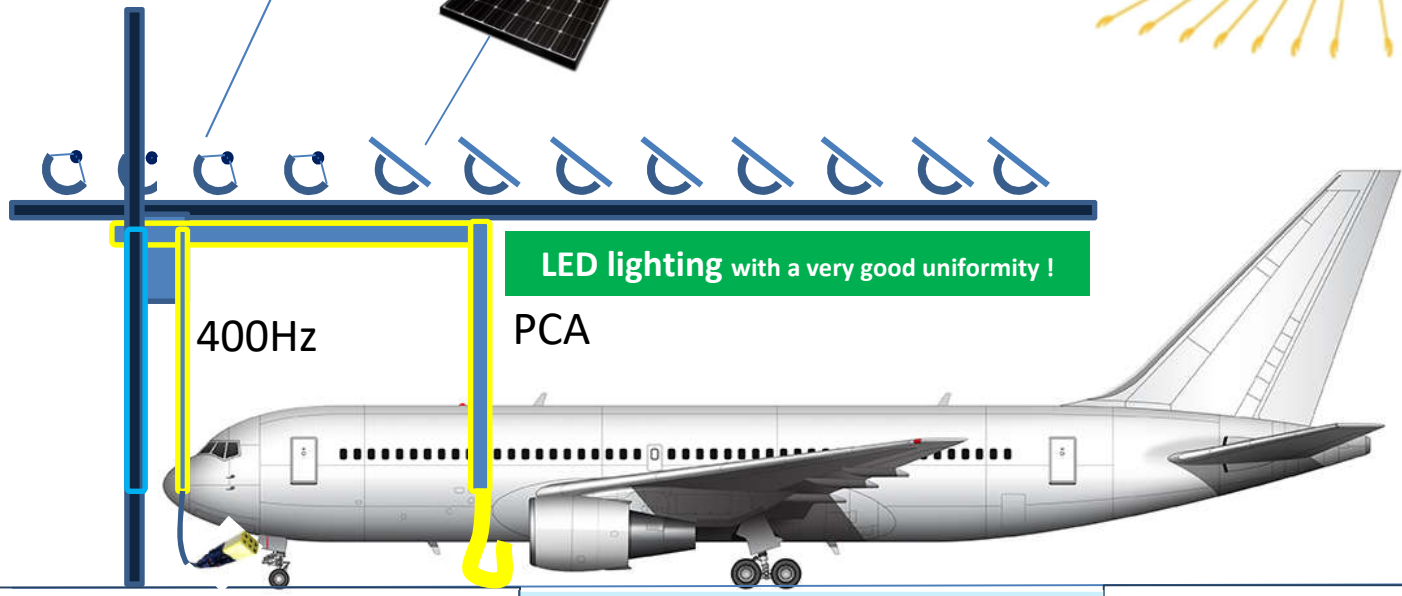
CONCEPT

Thermal SOLAR Modules (concentration)



PhotoVoltaic SOLAR panels





PCA

CSP - Concentrated Solar Power
+ Ammonia Absortion Reversible **Chiller**

COOLING POWER: 84 kWcool

Efficiency: 0.7 cooling / 1.4 heating
Safe Ammonia tank for energy storage
according to European Standards (< 150 kg)

SAFE:
STRONG structure resistance &
LOW exposure to wind

ANTIGLARE - ELECTROMAGNETIC COMPATIBILITY on airfield

GPU

Solar PV - Photovoltaic panels
+ micro-inverters technology

ELECTRICAL POWER: 100 kWp

Battery storage: 100 kWh (lower if network)
Static convector 400 HZ: 30 kVA
Network connection: Backup or Production

HELIO APRON

Green Airport

OPTIONS « Solar powered »

1. **Docking system**

2. **Mobile ramp**

3. **Aircraft pushback**

4. **Luggage lifting trolley & driver cart**

HELIO APRON

Economical analysis - Airports fees (C code aircraft)

Nice cote d'azur airport	$9.31 per arrival (€7.93 – 400Hz)
Marseille Provence airport	$26.04 per arrival (€22.19 – 400Hz)
Toulouse Blagnac airport	$25.74 per arrival (€21.93 – 400Hz)
Paris airports	$19.25 per arrival (€16.40 – 400Hz)
Zurich airport	$45.56 per arrival (FS45 – 400Hz + PCA)
Geneva airport	$50.62 per arrival (FS50 – 400Hz + PCA)
Munich airport	$76.28 per arrival (€65 – 400Hz + PCA)
Frankfurt airport	$43.83 per arrival (€37.35 – 400Hz + PCA)
AENA – Spanish airport	$43.42 per arrival (€37 – 400Hz)
Athens airport	$41.25 per arrival (€35.16 – 400Hz)
Turkish airports	$112.67 per arrival (€96 – 400Hz + PCA)
Brussels airport	$28.17 per arrival (€24 – 400Hz)
Miami airport	**$18.34 per arrival (only PCA)**

→ **AVERAGE: $40 per arrival (400Hz + PCA)**

HELIO APRON

Green Airport

Economical analysis R.O.I.

Investment cost from $750,000 to $1M per aircraft position
+ Yearly maintenance cost of 5 - 7% of the investissement cost.

Revenues=
$40 per arrival * 12 arrivals/day * 300 days/year = $144,000/year
+ Excess of power production (if network)
+ Hot water production (if terminal connection)

	0	1	2	3	4	5	6	7	8	9	10	11	12	TRI
	COST X $1,000	Cumulative values in $1,000												30 ans
1 remote Position without network	947	-851	-754	-657	-561	-464	-372	-280	-188	-96	-4	87	179	9%
2 remote Positions without network	905	-806	-708	-609	-510	-411	-317	-223	-129	-34	60	154	248	10%
5 remote Positions without network	857	-756	-655	-554	-453	-352	-255	-158	-61	36	133	230	326	11%
1 remote Position with network conn	839	-737	-635	-533	-431	-329	-231	-133	-35	62	160	258	356	11%
2 remote Positions with network con	799	-695	-591	-487	-383	-279	-179	-79	21	121	221	321	421	12%
5 remote Positions with network con	755	-648	-542	-436	-330	-223	-121	-18	84	187	289	392	494	14%
1 Position linked with terminal	829	-727	-624	-522	-419	-317	-218	-120	-22	77	175	273	372	12%
2 Positions linked with terminal	790	-686	-581	-477	-372	-268	-167	-67	34	134	235	336	436	13%
5 Positions linked with terminal	746	-639	-532	-426	-319	-212	-109	-6	97	200	303	406	509	14%

Return On Investment:
Between 7 & 10 years

Operation:
More than 30 years!

GO-GREEN

CONCLUSIONS

GO-GREEN

Green Airport

Resilient

IS NOT A DREAM BUT REALITY

SOLAR SOLUTIONS ARE EXISTING:

TO SERVE AND PROTECT AIRPORT OPERATIONS
TO DELIVER MORE ENERGY TO CITIES AND COUNTRY FROM SAFE AREAS
TO SAVE CARBON PRODUCTION AND PARTICIPATE IN CLIMATE CHANGE
TO IMPROVE AIR QUALITY
TO REDUCE NOISE IMPACT ON GROUND

What are we looking for?

Green Airport

GO-GREEN

An **AIRPORT !**

Its favorite **CONSULTANT !!**

A famous US **CONTRACTOR !!!**

*And of course the support from **the FAA's EXPERT ….** with the **VALE program.***

Gil DAVER at abroad.business.consulting@gmail.com
Mobile: +33 689 704 348